Laser Programmed Conducting Polymers

Final Report

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10 December, 1995

U.S. Army Research Office

29373-PH   19960212 070

Rice University

DTIC QUALITY INSPECTED 4

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 12/10/95	3. REPORT TYPE AND DATES COVERED Final 13 May 92 - 12 May 95

4. TITLE AND SUBTITLE

Laser Programmed Conducting Polymers

5. FUNDING NUMBERS

ARO MIPR 158-94

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

ARO 29373.10-PH

11. SUPPLEMENTARY NOTES

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12a. DISTRIBUTION/AVAILABILITY STATEMENT

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12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The metal insulator transition observed in excimer laser irradiated polyimide was characterized in terms of percolation theory. The critical exponent for electrical conductivity was measured to be 2.00+0.05 in exact agreement with the percolation theory predictions.
Carbon fiber formation under an applied electric filed was also observed and investigated. The observation of nonlinear I-V characteristics and the relation of this observation to the percolation theory is an object of continuing investigations.

14. SUBJECT TERMS

laser induced conductivity in polyimide
percolation
excimer lasers

15. NUMBER OF PAGES

5

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

A. Problem Studied

Laser induced electrical conductivity in polyimide was studied near the critical point. As the system has been described by percolation theory, characterization in terms of percolation threshold and critical exponents was sought.

B. Results

An *in situ* measurement technique was developed which allowed us to measure conduction during laser processing. A typical result is shown in Fig.1, where electrical conductivity is shown as a function of the number of laser pulses and the volume fraction of transformed material. The curve fits shown are for a power law of the form:

$$\sigma = (p - p_c)^t \qquad (1)$$

which is from the percolation theory [1] where p is the conducting volume fraction of the conductor insulator mixture and p_c is the critical volume fraction where the conductivity first appeared. Theory predicts that $t \sim 1.9\pm0.1$ [1] and the exponent found here was 2.00 ± 0.05 further confirming the percolation description of the phenomenon and perhaps making an experimentally precise confirmation of the percolation theory itself.

Also noted in the same study was the tendency for carbon fibers to form on the surface of samples when the applied voltage was high. These fibers would form in the first hundred laser pulses and had substantial electrical conductivities.
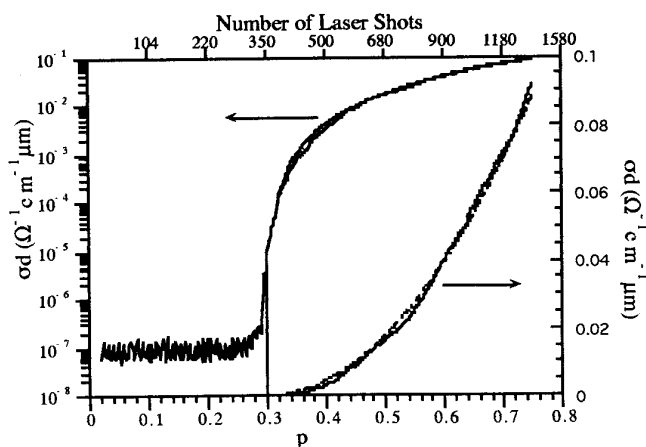

Fig.1. Conductivity as a function of the conducting volume fraction p and number of laser pulses. Curve fits correspond to power laws in percolation theory and agree exactly with theoretical predictions

Also of interest was the obervation of nonlinear I-V characteristics for samples near the threshold. The relation of this observation to the percolation theory is a subject of continuing interest.

Publications

Z. Ball, H.M. Phillips, D.L. Callahan, and R. Sauerbrey, "Percolative metal insulator transition in excimer laser irradiated polyimide", *Physical Review Letters* **73**, 2099 (1994)

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Personnel

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List of Figures